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Frontal sinus stenting in endoscopic sinus surgery: the 10-year Oxford experience*

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Abstract

Background. Frontal sinus stents have been introduced to reduce frontal sinus re-stenosis after surgery and to improve outcomes.
Method. This study was a retrospective analysis of 19 patients who had endoscopic sinus surgery with approach to the frontal sinus and insertion of a soft sinus stent.
Results. The frontal recess was patent in 78.9 per cent and stenosed in 21.1 per cent of patients; no completely closed recesses were observed. Mean follow up was 20.7 months, and time period of stenting was 9.8 months on average; complications were observed in 47.4 per cent of the patients, with post-operative sinonasal infection being the most common.
Conclusion. In the authors' experience, indications for frontal sinus stenting include recalcitrant chronic rhinosinusitis after multiple functional endoscopic sinus surgeries (especially in chronic rhinosinusitis with nasal polyps), patients with history of important craniofacial surgery or trauma, and recurrent mucoceles. The stent was overall well tolerated as only minor complications were observed. Close clinical follow up is mandatory.

Main Article

Fabrizio Bandino takes responsibility for the integrity of the content of the paper

*The online version of this article has been updated since original publication. A notice detailing the change has also been published

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Introduction

Functional endoscopic sinus surgery (FESS) is a well-accepted and effective procedure for treating chronic rhinosinusitis, with the main aim of restoring the ventilation of the diseased paranasal sinuses and creating a cavity that is accessible to topical medical therapy.[1] Functional endoscopic sinus surgery of the frontal sinus has been shown to be a particularly challenging surgery[1,2] because of the fact that the frontal infundibulum is one of the most anatomically complex and difficult to access areas of the paranasal sinuses.[3] The small diameter, the close relationship with the orbit and the skull base as well as its anterior location and orientation are all contributing factors.[4] Revision frontal sinus surgery is even more challenging.[5] Over the years, several procedures have been described to improve frontal sinus access. Whereas in the past the frontal sinus was mainly addressed using external approaches, especially in cases of recalcitrant or complicated chronic frontal sinusitis; more recently endoscopic approaches have taken their place.[4]

Many authors have reported their outcomes using different techniques, but one of the main issues found in long-term follow up is sinusotomy patency.[4] Because of the aforementioned factors, as well as peri-operative (i.e. extension of frontal sinusotomy) and post-operative (optimisation of the post-operative wound-healing process) conditions,[1] the frontal recess seems to be more prone to re-stenosis with subsequent occlusion of the outflow tract,[1,6–8] which thus reflects in a lower success rate compared with the other sinuses.[1] In fact, a high failure rate and disease recurrence, as a consequence, have been reported in up to one third of the patients,[6,8,9] with 10 per cent requiring revision surgery at 3 years and 20 per cent at 5 years, independently from the type of approach used (external or endonasal) and the extension of the sinusotomy achieved.[1,4,10,11]

In order to decrease the rate of synechiae and stenosis, stents have been introduced. These primarily aim to separate the edges of the wound surfaces, to prevent synechial band formation and subsequent stenosis, to take up space that would otherwise be filled with blood, fibrin and/or mucus (and so decreasing the need for post-operative debridement), and to provide a matrix for epithelial migration (especially in areas of denuded bone).[5] Stents have been implanted in almost every site of the human body and have been used in nearly all the medical subspecialties.[12] Since the early 1900s,[9] the same principles have been applied for frontal sinus stents and spacers, initially using external approaches and, more recently, following endoscopic ones.[1,4,6,8] Over the years, several types of stents have been proposed, including absorbable and non-absorbable, self-retaining or non-self-retaining, drug-eluting (steroid,[11,13–15] antibiotic,[16] anti-neoplastic[1,17]), stents of different materials (silastic,[18,19] gold,[3] silicon,[7,20] pigtail[17]), and different shapes (double J[5] or silastic sheet[4]). So far, there are no guidelines on the best type of stent,[6–8] indications and duration of stenting. Theoretically, time period of stenting should be long enough to allow a good and stable re-mucosalisation[1] of the frontal pathway, even though safety concerns have been raised with regard to prolonged

stenting.[21] Moreover, other complications related to the stent implantation include spontaneous dislocation and migration (14 per cent),[12,22] obstruction (5 per cent),[22] scarring and granulation,[12,23] infection,[12,23] toxic shock syndrome because of *Staphylococcus aureus* infection,[24] skull base erosion[9] and stent hypersensitivity.[12]

The purpose of this study was to retrospectively assess the short- and long-term effectiveness, safety and indications for the use of a soft, self-retaining and non-absorbable sinus stent in the treatment of recalcitrant chronic rhinosinusitis of the frontal sinus, with the aim of evaluating the role of this device in maintaining the frontal sinus ostium patency and preventing symptom recurrence.

Materials and methods

We performed a retrospective review of patients undergoing FESS to the frontal sinus with insertion of a sinus stent at Oxford University Hospitals between October 2011 and May 2021.

Population data including age, sex, co-morbidities, history and number of previous FESS, presenting symptoms, indications to surgery, pre-operative and post-operative computed tomography (CT) scan findings, time period of stenting and of follow up were collected. All patients were reviewed by a rhinologist, and a pre-operative CT scan was arranged for all patients for surgical planning. Indications for frontal sinus stenting included: (1) a history of failed multiple FESS procedures (in particular, patients with chronic rhinosinusitis with nasal polyps) with restenosis of the previous frontal sinusotomy, (2) complicated history (i.e. previous important craniofacial trauma or surgery) and (3) recurrent mucoceles where it was difficult to obtain a complete marsupialisation because of contiguity to vital structures. All the procedures were performed by the same senior ENT surgeon (PM-D).

The present investigation was conducted in accordance with the 1996 Helsinki Declaration. All investigations and treatments were carried out in line with accepted clinical practice, and informed consent was obtained from each subject before starting any study-related procedure. The study had clinical governance authorisation, and it fell under local audit guidelines. Thus, no ethical approval was required.

Surgical technique

All patients underwent FESS with frontal sinusotomy (Draf I, II or III procedures) and frontal sinus stenting under general aesthesia following the surgical technique previously described by our group.[25] Briefly, a frontal sinusotomy is performed to obtain a good frontal sinus opening with extension depending on the CT scan findings and patient's disease. A paediatric Montgomery T-tube stent of the correct diameter (range, 6–9 mm) is cut and shaped according to the sinusotomy performed ('straight' if Draf I, IIa or IIb; 'Y-shaped' if Draf III). It is then introduced intranasally under endoscopic vision and advanced into the frontal recess. When required, the nose is packed using either Stammberger Sinu-Foam® and/or Nasopore® and/or Floseal®.

Patients are discharged on regular nasal douches, long-term intranasal steroid drops (fluticasone nasal drops 400 µg (1 mg/ml) twice daily) and a short course of oral antibiotics, depending on previous microbiology results. An out-patient follow up is arranged at six weeks for endoscopic debridement. Patients are followed up every 3 to 6 months with regular endoscopic evaluation to confirm stent position. The stent is removed in the out-patient clinic department under local anaesthesia whenever it gets dislocated, extruded, blocked, is no longer tolerated by the patient or if the patient needs revision surgery in the operating room under general anaesthesia.

Statistical analysis

Quantitative variables were described using their mean with minimum and maximum values, and qualitative variables were described as numbers and percentages. Statistical comparisons were performed using the Mann–Whitney U test and Kruskal–Wallis test for quantitative variables and chi-square and Fisher's exact test for qualitative variables. Results were considered significant at the uncertainty level of 5 per cent ($p < 0.05$).

Results

Population

From October 2011 to May 2021, 1242 patients underwent FESS with 248 patients undergoing frontal sinus surgery; of these, a subgroup of 19 patients (18 adults; 7.7 per cent) had insertion of a stent in the frontal sinuses. Seventeen patients (89.5 per cent) had a history of previous FESS with a median number of 2 FESS procedures before being listed for frontal sinus stenting. Frontal headache (18 patients; 94.7 per cent) and recurrent sinusitis (16 patients; 84.2 per cent) were the most commonly reported symptoms on presentation. Mucocele was the most frequent indication for surgery (10 patients; 52.6 per cent) followed by chronic rhinosinusitis with nasal polyps (5 patients; 26.3 per cent) and chronic rhinosinusitis without nasal polyps (4 patients; 21.1 per cent). Eleven patients (57.9 per cent) had signs of neo-osteogenesis at their pre-operative CT scan. The median time period of stenting was 7 months (range, 0–36 months) while the median length of follow up was 18 months (range, 0–79 months). A post-operative CT scan was organised for 9 patients (47.4 per cent) for medical and/or surgical reasons. This showed signs of neo-osteogenesis in 8 patients (88.9 per cent). General characteristics of the whole population and according to time period of stenting (less than or equal to or more than 6 months) are reported in Table 1.

Although we observed a higher number of patients with chronic rhinosinusitis with nasal polyps who needed stents for more than six months, this was not statistically significant, and no statistically significant differences in the general characteristics were noted when dividing patients according to time period of stenting (less than or equal to or more than 6 months).

Surgical details and post-operative outcomes

In the majority of the cases, frontal sinus stenting was associated with Draf III (13 patients; 68.4 per cent) and was performed bilaterally (10 patients; 52.6 per cent) and under image guidance (15 patients; 78.9 per cent). A 7-mm paediatric Montgomery T-tube was the most commonly used stent (9 patients; 47.4 per cent), and in most of the cases the Stammberger Sinu-Foam alone (12 patients; 70.6 per cent) was used as nasal dressing. Four patients (21.1 per cent) required Nasopore as an additional post-operative nasal packing while Floseal was used only in 1 (5.3 per cent) patient to reduce the risk of post-operative nasal bleeding. The most

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Table 1. General characteristics of the whole population and according to time period of stenting (< or ≥6 months)

Parameter	Total population*	Stenting <6 months†	Stenting ≥6 months‡	*P*-value
Age (median (minimum–maximum); years)	50 (12–84)	37.5 (12–72)	58 (38–84)	0.5
Sex (*n* (%))				
– Male	13 (68.4)	4 (50.0)	9 (31.6)	0.3
– Female	6 (31.6)	4 (50.0)	2 (68.4)	
Co-morbidities (*n* (%))	15 (78.9)	7 (87.5)	8 (72.7)	0.6
History of previous FESS (*n* (%))	17 (89.5)	6 (75.0)	11 (100)	0.2
Number of FESS (median (minimum–maximum); *n*)	2 (1–5)	2 (1–5)	2 (1–3)	1
Presenting symptoms (*n* (%))				
– Frontal headache	18 (94.7)	7 (87.5)	11 (100)	0.4
– Recurrent sinusitis	16 (84.2)	7 (87.5)	9 (81.8)	1
– Nasal obstruction	5 (26.3)	2 (25.0)	3 (27.3)	1
– Orbital symptoms	6 (31.6)	3 (37.5)	3 (27.3)	1
Indication to surgery (*n* (%))				
– Mucocele	10 (52.6)	4 (50.0)	6 (54.5)	1
– Chronic rhinosinusitis with nasal polyps	5 (26.3)	4 (50.0)	1 (9.1)	0.1
– Chronic rhinosinusitis without nasal polyps	4 (21.1)	0 (0.0)	4 (36.4)	0.1
Pre-operative CT scan (*n* (%))				
– Yes	19 (100)	8 (100)	11 (100)	
– No	0 (0.0)	0 (0.0)	0 (0.0)	1
– Neo-osteogenesis	11 (57.9)	5 (62.5)	6 (54.5)	1
Post-operative CT scan (*n* (%))				
– Yes	9 (47.4)	4 (50.0)	5 (45.4)	
– No	10 (52.6)	4 (50.0)	6 (54.6)	1
– Neo-osteogenesis	8 (88.9)	3 (75.0)	5 (100)	0.4
Time period of stenting (median (minimum–maximum); months)	7 (0–36)	1.5 (0–5)	9 (6–36)	–
Length of follow up (median (minimum–maximum); years)	18 (0–79)	3.5 (1–37)	25 (4–79)	0.3

*$n = 19$; †$n = 8$; ‡$n = 11$. Level of significance $p < 0.05$. FESS = functional endoscopic sinus surgery; CT = computed tomography

commonly recorded complication was stent dislocation (9 patients; 47.4 per cent) followed by sinonasal infection (6 patients; 31.6 per cent) and stent obstruction (3 patients; 15.8 per cent). The median length of admission after frontal stenting was 1 day (range, 0–58 days).

At the last out-patient follow up attended, the frontal stent was patent in 15 patients (78.9 per cent), and it was partially blocked (stenosed) in the remaining patients (4 patients; 21.5 per cent). Four patients (21.0 per cent) required stent replacement because of stent blockage or extrusion; the stent was removed in the other 6 patients (31.6 per cent). This was performed under local anaesthesia in the out-patient department for 4 patients (66.7 per cent) and under general anaesthesia in the operating room for the remaining 2 patients (33.3 per cent). The mean time period of stenting before removal was 10.7 months (range, 1–25 months). Table 2 reports the surgical details of the whole population and according to time period of stenting (less than or equal to or more than 6 months). Table 3 reports the list of all patients and corresponding findings.

No statistically significant differences in the surgical details and post-operative outcomes were noted when dividing patients according to time period of stenting (less than or equal to or more than 6 months). Stents were retained for a significantly longer period in patients who underwent Draf III (average of 10.3 months) compared with 7.9 months for Draf I, 4.5 months for Draf IIa and 2 months for Draf IIb ($p = 0.04$).

Primary pathology

Comparison between the different primary pathologies (chronic rhinosinusitis with nasal polyps: 4 patients (21.1 per cent) *vs* chronic rhinosinusitis without nasal polyps: 5 patients (26.3 per cent) *vs* mucocele: 10 patients, 52.6 per cent) showed a statistically significant difference in size of the stent, with the 6 mm Montgomery T-tube being more used in the mucocele group ($p = 0.03$), and time period of stenting in the chronic rhinosinusitis with nasal polyps group (mean, 14.8 months *vs* 2.4 in the chronic rhinosinusitis without nasal polyps group and 11.6 months in the mucocele group; $p = 0.04$); no other statistically significant differences were found when comparing the three populations.

Stents spontaneously extruded

Stents were spontaneously extruded in 6 patients (31.6 per cent); in this subgroup of patients, we observed a higher rate

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Table 2. Surgical details of the whole population and according to time period of stenting (< or ≥6 months)

Parameter	Total population*	Stenting <6 months†	Stenting ≥6 months‡	*P*-value
Procedure associated with stenting (*n* (%))				
– Frontal balloon dilatation	3 (15.8)	1 (12.5)	2 (18.2)	1
– Draf 1	3 (15.8)	1 (12.5)	2 (18.2)	1
– Draf 2a	2 (10.5)	2 (25.0)	0 (0.0)	0.2
– Draf 2b	1 (5.3)	1 (12.5)	0 (0.0)	0.4
– Draf 3	13 (68.4)	4 (50.0)	9 (81.8)	0.3
Laterality (*n* (%))				
– Unilateral	9 (47.4)	6 (75.0)	3 (27.3)	
– Bilateral	10 (52.6)	2 (25.0)	8 (72.7)	0.1
Image-guidance (*n* (%))	15 (78.9)	6 (75.0)	9 (81.8)	1
Size of stent (*n* (%))				
– 6 mm	7 (36.8)	3 (37.5)	4 (36.4)	1
– 7 mm	9 (47.4)	4 (50.0)	5 (45.4)	1
– 8 mm	2 (10.5)	1 (12.5)	1 (9.1)	1
– 9 mm	1 (5.3)	0 (0.0)	1 (9.1)	1
Nasal packing (*n* (%))				
– No	2 (10.5)	1 (12.5)	1 (9.1)	
– Yes	17 (89.5)	7 (87.5)	10 (90.9)	1
Tye of nasal (*n* (%))				
– Stammberger Sinu-Foam	12 (70.6)	7 (100)	5 (50.0)	0.1
– Stammberger Sinu-Foam + Nasopore	4 (21.1)	0 (0.0)	4 (40.0)	0.1
– Stammberger Sinu-Foam + Nasopore + Floseal	1 (5.3)	0 (0.0)	1 (10.0)	0.1
Complications (*n* (%))				
– Stent dislocation	9 (47.4)	2 (12.5)	7 (63.6)	0.2
– Sinonasal infection	6 (31.6)	1 (25.0)	4 (40.0)	1
– Stent obstruction	3 (15.8)	1 (12.5)	2 (18.2)	1
– Crusting	2 (10.5)	1 (12.5)	1 (9.1)	1
– Granulation tissue/foreign body reaction	2 (10.5)	0 (0.0)	2 (18.2)	0.5
– Ocular complications	1 (5.3	1 (12.5)	0 (0.0)	1
– Synechiae/adhesions	1 (5.3)	0 (0.0)	1 (9.1)	1
– Mucocele	1 (5.3)	0 (0.0)??	1 (9.1)??	1
– Meningitis	1 (5.3)	1 (12.5)	0 (0.0)	0.4
Length of admission (median (minimum–maximum); days)	1 (0–58)	1 (0–58)	1 (1–4)	0.8
Stent status at last follow up (*n* (%))				
– Patent	15 (78.9)	5 (62.5)	10 (90.9)	0.3
– Stenosed	4 (21.5)	3 (37.5)	1 (9.1)	0.3
Stent replacement (*n* (%))	4 (21.0)	1 (12.5)	3 (27.3)	0.6
Stent removal (*n* (%))	12 (63.2)	6 (75.0)	6 (54.5)	0.6

*$n = 19$; †$n = 8$; ‡$n = 11$. Level of significance $p < 0.05$. CT = computed tomography

of stenosed frontal recess at their last follow up (3 patients, 50.0 per cent *vs* 1 patient, 7.7 per cent in the non-spontaneously extruded group) and, conversely, a lower rate of patent frontal recess (3 patients, 50.0 per cent *vs* 12 patients, 92.3 per cent, in the non-spontaneously extruded group; data not statistically significant). In this subpopulation, time period of stenting was shorter (mean, 5 months *vs* 12.1 months in the non-spontaneously extruded group; data not statistically significant) and the stent was replaced in 2 patients (33.3 per cent; data not statistically significant). No other statistically significant differences were noted when comparing the two groups, including revision surgery and complication rate.

Discussion

Surgical treatment of chronic frontal sinusitis is affected by a high failure rate.[3] To overcome that, intra-operative insertion of frontal sinus stents has been described as an option to

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Table 3. List of patients and findings

Patient number	Gender	Age (years)	Draf procedure	Size of stent (mm)	Previous FESS (*n*)	Indication for surgery	Length of follow up (months)	Last follow up endoscopic evaluation of frontal recess	Complications	Stent removal	Time period of stenting (months)	Revision surgery (*n*)
1	Male	84	1	8	Yes (3)	Mucocele	4	Patent	No	No	7	No
2	Male	44	3	6	Yes (5)	CRSsNP	2	Stenosed	No	Spontaneously extruded	0	No
3	Male	50	3	7	Yes (1)	CRSwNP	25	Patent	Stent dislocation	OPD (LA)	9	Yes (1)
4	Male	69	3	6	Yes (3)	CRSwNP	79	Stenosed	Crusting; granulation tissue; infection; stent dislocation; stent obstruction	Spontaneously extruded	6	Yes (4)
5	Male	39	3	7	Yes (1)	CRSsNP	39	Patent	Mucocele	No	7	Yes (1)
6	Female	36	1	7	No (0)	Mucocele	27	Stenosed	Stent obstruction	OPD (LA)	1	No
7	Male	12	2a	7	Yes (1)	Mucocele	18	Patent	Infection	Spontaneously extruded	5	No
8	Male	66	3	6	Yes (3)	CRSwNP	24	Patent	Adhesions; stent dislocation; stent obstruction	Operating theatre (GA)	19	Yes (2)
9	Female	32	2a	7	No (0)	Mucocele	37	Stenosed	Crusting; stent dislocation	Spontaneously extruded	4	Yes (3)
10	Male	79	3	7	Yes (3)	Mucocele	36	Patent	No	No	36	No
11	Male	58	3	7	Yes (1)	Mucocele	7	Patent	Infection; stent dislocation	No	7	Yes (1)
12	Female	55	1	7	Yes (2)	Mucocele	34	Patent	No	No	34	No
13	Male	72	3	8	Yes (2)	CRSsNP	5	Patent	Infection	Operating theatre (GA)	3	Yes (1)
14	Male	41	3	9	Yes (1)	Mucocele	13	Patent	Stent dislocation	Spontaneously extruded	13	No
15	Male	38	3	6	Yes (2)	CRSwNP	25	Patent	Infection; stent dislocation	OPD	25	No
16	Female	72	3	6	Yes (3)	Mucocele	14	Patent	Granulation tissue; infection; stent dislocation	OPD	7	No
17	Female	34	2b	7	Yes (2)	Mucocele	2	Patent	Stent dislocation	Spontaneously extruded	2	No
18	Male	57	3	6	Yes (1)	CRSsNP	1	Patent	No	No	1	No
19	Female	39	3	6	Yes (2)	CRSwNP	1	Patent	No	No	1	No

FESS = functional endoscopic sinus surgery; CRSsNP = chronic rhinosinusitis without nasal polyps; CRSwNP = chronic rhinosinusitis with nasal polyps; OPD = out-patient department; LA = local anaesthesia; GA = general anaesthesia

maintain frontal recess patency. The concept of frontal sinus stenting is based on the theory that stenosis may be because of a mucosal injury with the presence of exposed bone, persistent blood, debris and granulation tissue in the frontal recess. This could lead to an abnormal healing process characterised by scarring, osteogenesis and re-stenosis. In this regard, stents may contrast these factors, allowing enough time for a stable re-mucosalisation.[4]

According to previous studies,[9] indications for frontal sinus stenting include: a diameter of the opening of less than 5 mm, purulence, osteitic bone, granulomatous inflammation because of vasculitis, stenosis from previously failed sinus surgery, middle turbinate lateralisation, denuded bone within the frontal recess, severe polyposis and aspirin intolerance. As observed before,[26] our study showed that stenting of the frontal sinus is rarely necessary; in our 10-year series, we used frontal sinus stents in about 7.7 per cent of all the endoscopic frontal sinus procedures performed. In particular, stenting was used in patients with history of failed multiple FESS (in particular patients with chronic rhinosinusitis with nasal polyps), complicated history (i.e. previous important craniofacial trauma or surgery) and recurrent mucoceles where it was difficult to obtain a complete marsupialisation. Stent size was chosen to fit the diameter of the frontal recess reached at the end of the procedure; it is interesting to observe that mucoceles often needed a smaller Montgomery T-tube (data statistically significant).

All our patients had a pre-operative CT scan that showed neo-osteogenesis in the majority, a sign that reflects the presence of osteitis and active bone activity which can be considered a risk factor for re-stenosis. Our surgical technique was previously described in Bandino *et al.*[25]; because of its shape, the stent was self-retaining and there was no need to use any suture to anchor it. Whenever available, we advocate the use of image-guided systems to facilitate stent insertion.[4] Given that a stent represents a foreign body, there should be a documented, informed discussion and good counselling with patients before the surgery.[23]

In our series, stenting after a Draf III was the most commonly performed procedure[4]; in this group of patients, a stent was more likely to be retained for a longer period (average of 10.31 months *vs* 7.86 months for Draf I, 4.50 months for Draf IIa and 2 months for Draf IIb; $p = 0.04$), probably because of the different shape and position. One third of patients had the stent removed during their follow up, with this being performed under local anaesthesia in an out-patient setting in the majority of the cases, and it was generally well tolerated. Three patients had balloon sinuplasty followed by Draf I for 1 patient and Draf III for the other two with placement of stents because we felt that the diameter of the frontal recess reached with balloon sinuplasty was not enough to prevent re-stenosis.

All our patients routinely had post-operative medical care which consisted of saline douches, oral antibiotics and topical steroids. Although we perform routine post-operative debridement, it is difficult to know whether stenting would have reduced the need for it.[4] Because of the possibility of complications, we advocate regular follow ups until the stent is removed. Follow up should happen at least yearly and requires a nasal endoscopy; although a stent is radiopaque, we do not advocate regular radiological follow up,[9] unless there are complications or new sinonasal symptoms.

No consensus exists on the optimal time period of stenting.[7] The general recommendation is that stenting should last at least six months,[9,26] which is the average time that allows a stable and complete re-mucosalisation of the frontal sinus pathway. Although a short-term stent does not seem to reduce re-stenosis rate,[4] a long-term stent has not been recommended because of safety concerns.[8] However, the results in the literature are still contradictory. In our series, the time period of stenting was about nine months on average; this represents a longer period of time compared with other studies mentioned below. We observed a higher success rate in the group with stenting longer than 6 months (frontal recess was patent in 90.9 per cent of the patients compared with 62.5 per cent in the group with stenting for less than 6 months), but this data was not statistically significant. We measured the clinical outcome of patency of the neo-ostium of the frontal recess at the last follow-up endoscopic examination,[4] and we observed that almost 80 per cent of the frontal recesses were patent, which is similar to what has been observed before with other materials (80–94 per cent).[9,27] We did not observe any complete closures of the frontal sinusotomy. It is interesting to observe that in patients where the stent spontaneously extruded, time period of stenting was shorter (mean, 5 *vs* 12.1 months in the non-spontaneously extruded group) and the frontal recess was more frequently stenosed (data not statistically significant), suggesting that the stent may have an important role in keeping the frontal recess patent. Another important finding is that, in order to have similar outcomes, patients with chronic rhinosinusitis with nasal polyps needed a longer time period of stenting (data not statistically significant).

Despite our study confirming a good patency rate of the frontal sinus recess, one third of our patients required revision surgery for recurrent symptoms. Interestingly, the revision surgery rate was higher in the group of patients with frontal stenting longer than six months, but this was not statistically significant and may reflect a more complicated frontal sinus disease. In this regard, some patients will continue to have symptoms of frontal sinusitis, despite a patent frontal sinus recess, and the underlying mechanism remains partially unknown. In these patients, poor mucociliary clearance may explain their chronic symptoms,[8] and the use of a frontal stent, and steroid-eluting, may not necessarily resolve these or provide additional benefit.

Although complications are not uncommon (almost 50 per cent of our patients had them), in our series the majority of complications were minor ones with no major complications recorded. The most common complication observed was stent dislocation followed by infection. In particular, presence of infection may be related to the underlying chronic sinus disease rather than to the presence of the stent itself, although bacterial colonisation with possible biofilms of the stent has been previously described for other materials.[12] Stent obstruction, granulation or crusting was not common, suggesting that the stent may help with the process of re-mucosalisation.[8] We observed a similar complication rate in both groups of short- and long-stenting. In one third of our patients, a stent was spontaneously extruded during the follow up, but we did not observe any stent aspiration. One patient developed meningitis which resolved with medical treatment and was a result of infection of mucocele.

Our study has some limitations. It is a retrospective series with a small sample size, which makes a generalisation of the observed results difficult. Stenosis of the frontal recess may also appear several years following frontal sinus stent insertion and, therefore, a longer follow up is needed to confirm our findings.

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Conclusion

Surgery of the frontal sinus remains challenging and is affected by a high failure rate. In patients with recalcitrant chronic rhinosinusitis, recurrent mucoceles, and patients with history of important craniofacial surgery or trauma, frontal sinus stenting may be beneficial and help keep the frontal recess open.

Our case series, although small, shows how soft and self-retaining stents (as with the paediatric Montgomery T-tube described here) may be effective, safe and well tolerated both in the short- and long-term period.

- Surgery for chronic rhinosinusitis of the frontal sinus remains challenging and is prone to failure in about one third of the patients, regardless of the procedure performed
- In order to reduce frontal sinus re-stenosis and improve outcomes, frontal sinus stents have been used; however, short- and long-term effectiveness, safety and correct indications are not widely known
- This study described a 10-year experience on the use of a soft, self-retaining and non-absorbable modified Montgomery T-tube acting as a frontal sinus stent
- Indications for stenting are recalcitrant chronic rhinosinusitis after multiple previous functional endoscopic sinus surgeries, history of important craniofacial surgery or trauma and recurrent mucoceles
- Stenting was overall well tolerated as only minor complications were observed; close clinical follow up is mandatory

Because of the fact that the stent may spontaneously extrude, close clinical follow up is mandatory and imaging should be reserved for patients with complications or worsening symptoms following stent insertion.

Competing interests. None declared.

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